Acoustical Scattering, Propagation, and Attenuation Caused by Two Abundant Pacific Schooling Species: Humboldt Squid and Hake

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LONG-TERM GOALS

Our long-term goal is to predict the acoustic characteristics expected from aggregations of hake and jumbo squid off the west coast of North America within the frequency range of tactical, low to mid-frequency naval sonars.

OBJECTIVES

Our objectives are to:

- Measure the material properties of jumbo squid and hake
- Characterize the inhomogeneity of these properties and identify important scattering mechanisms
- Develop target strength models for both species as a function of frequency and depth
- Measure target strength of individuals of both species to validate models
- Measure in situ the spatial and temporal distributions of squid and hake
- Develop propagation, attenuation, and scattering models for these aggregations

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APPROACH

To accomplish our goal of predicting the in situ scattering, propagation, and attenuation from monospecific and mixed schools of squid and hake, we will combine information from field surveys of aggregations with measurements of the biological and physical habitat surrounding these aggregations to identify key parameters related to the distribution and behavior of these animals. These parameters will be used to create probability surfaces for aggregations of various types. These surfaces will be combined with the acoustic scattering models to predict the range of acoustic scattering expected from this biologically created acoustic uncertainty under given environmental conditions.

WORK COMPLETED

This project is part of a larger Basic Research Challenge initiative. To that end, we are coordinating our field efforts with those of other teams of investigators, identifying data gaps, and working to obtain data for modelers. We participated in one, all PI meeting to kick off this project as well as several conference call. Benoit-Bird is organizing the second PI meeting this quarter.

As part of this project, we are collaborating with NOAA Fisheries. NOAA just completed its biennial survey for hake. We are beginning to examine this data to determine the patterns present for guidance of a focused research effort this winter.

Both PIs have successfully recruited graduate students that will conduct thesis research as part of this project.

RESULTS

Both hake and Humboldt squid form aggregations at a range of individual densities including true schools where individuals are polarized and coordinated. Before the invasion of Humboldt squid into the California current in the mid 1990's, aggregations of hake were shown to be the strongest biological sources of low frequency (e.g. hundreds of Hz to tens of kHz) acoustic scattering off the US West coast Given the similarities in the scattering of individual hake and jumbo squid, it is highly likely that aggregations of squid show similarly strong scattering within the frequency band of tactical naval sonars. Preliminary measurements shot that aggregations of Humboldt squid and hake can be found in close proximity to each other and even in mixed aggregations (Figure 1). It is not clear if this mixing will affect the multiple scattering from these aggregations and thus complicate predictions of scattering and propagation. The physical and acoustic characteristics of these species must be measured and modeled both alone and together to fully accomplish the goal of predicting the range, variability, and uncertainty from biologically-created acoustic scattering in the coastal North Pacific.

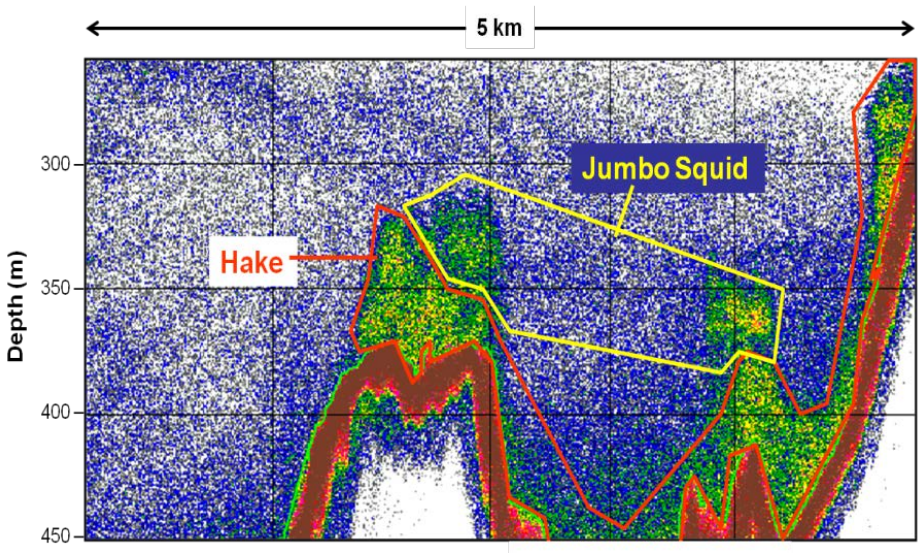

***Figure 1. An echogram recorded at 38 kHz during NOAA's 2009 hake survey about 80 nmi south of the US-Canadian border. Large aggregations of hake and squid, confirmed by trawls equipped with a* video camera, were found in close proximity to each other and showed broadly similar scattering strengths and characteristics despite their differences in morphology.**

IMPACT/APPLICATION

The use of acoustics in coastal waters for sensing and detection requires understanding the natural sources of variance in propagation, attenuation, and scattering. Recent work has revealed that aggregations of fish and other biota are, in some cases, the largest sources of this variance. We will extend these studies to make quantitative predictions about scattering, propagation, and attenuation at low to mid frequencies from aggregations of two abundant, large species off the west coast of North America, an important navy tactical and training area. These species have remarkably different morphologies and internal characteristics, yet both show strong scattering over the same range of frequencies, presenting a unique opportunity to evaluate the mechanisms of scattering from individual animals as well as mono- and hetero-specific aggregations. The models, measurements, and predictions resulting from this work will be directly applicable to naval operations within the habitat of hake and squid and will extend our general understanding of biologically driven acoustic processes.

TRANSITIONS

None at this time.

RELATED PROJECTS

This work is part of a Basic Research Challenge initiative of Fish Acoustics and is related to the other projects within this initiative. Most notably, some field work for this project will be conducted in conjunction with efforts by Gauss et al. and Diachok.

REFERENCES

N/A

PUBLICATIONS (refereed)

None

HONORS/AWARDS/PRIZES

Dr. Benoit-Bird has received a number of prestigious awards over the past few years, most notably a MacArthur Fellowship in 2010.

2007 National Academy of Sciences
2008 American Geophysical Union
2009 Acoustical Society of America
2010 **MacArthur Fellowship**, John D. and Catherine T. MacArthur Foundation